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Lee et al.

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(54) **METHOD FOR FABRICATING A PLURALITY OF ELASTIC PROBES IN A ROW**

(58) **Field of Classification Search** 29/825, 29/827, 829-846, 847, 848, 849, 874, 876, 29/881-885; 174/253, 254, 261, 267; 324/474, 324/761, 762; 361/772-776, 791
See application file for complete search history.

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(*) **Notice:** Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 0 days.

(57) **ABSTRACT**

A method of forming a plurality of elastic probes in a row is disclosed. Firstly, a substrate is provided, then, a shaping layer is formed on the substrate so as to offer two flat surfaces in parallel. A photoresist layer is formed on the substrate and on the shaping layer. Then, the photoresist layer is patterned to form a plurality of slots crossing an interface between the two flat surfaces where a plurality of elastic probes are formed in the slots. In one embodiment, the interface is an edge slope of the shaping layer so that each of the elastic probes has at least an elastic bending portion. During chip probing, the shifting direction of the elastic probes due to overdrives is perpendicular to the arranging direction of the bonding pads so that the elastic probes are suitable for probing chips with high-density and fine-pitch bonding pads.

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(30) **Foreign Application Priority Data**

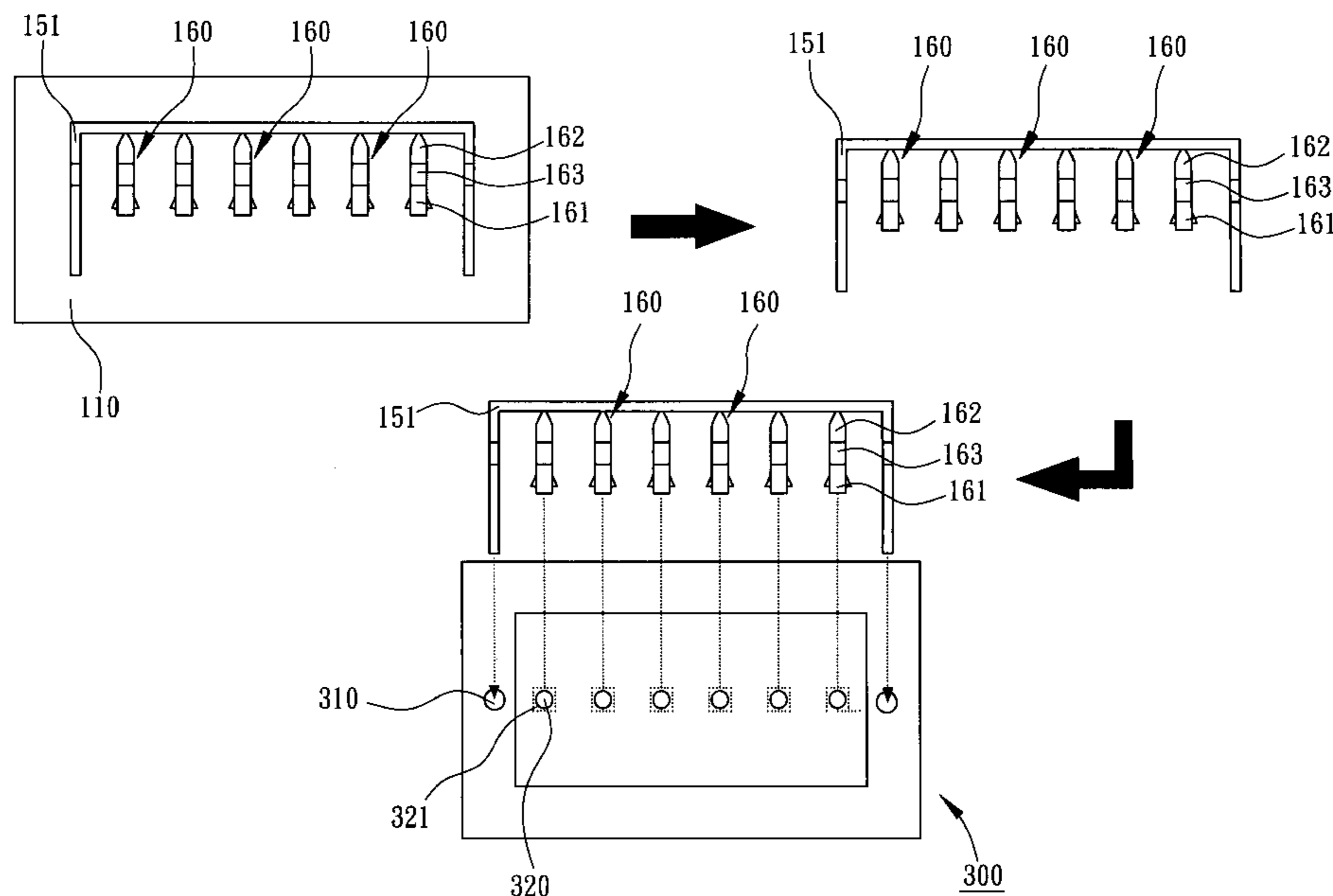
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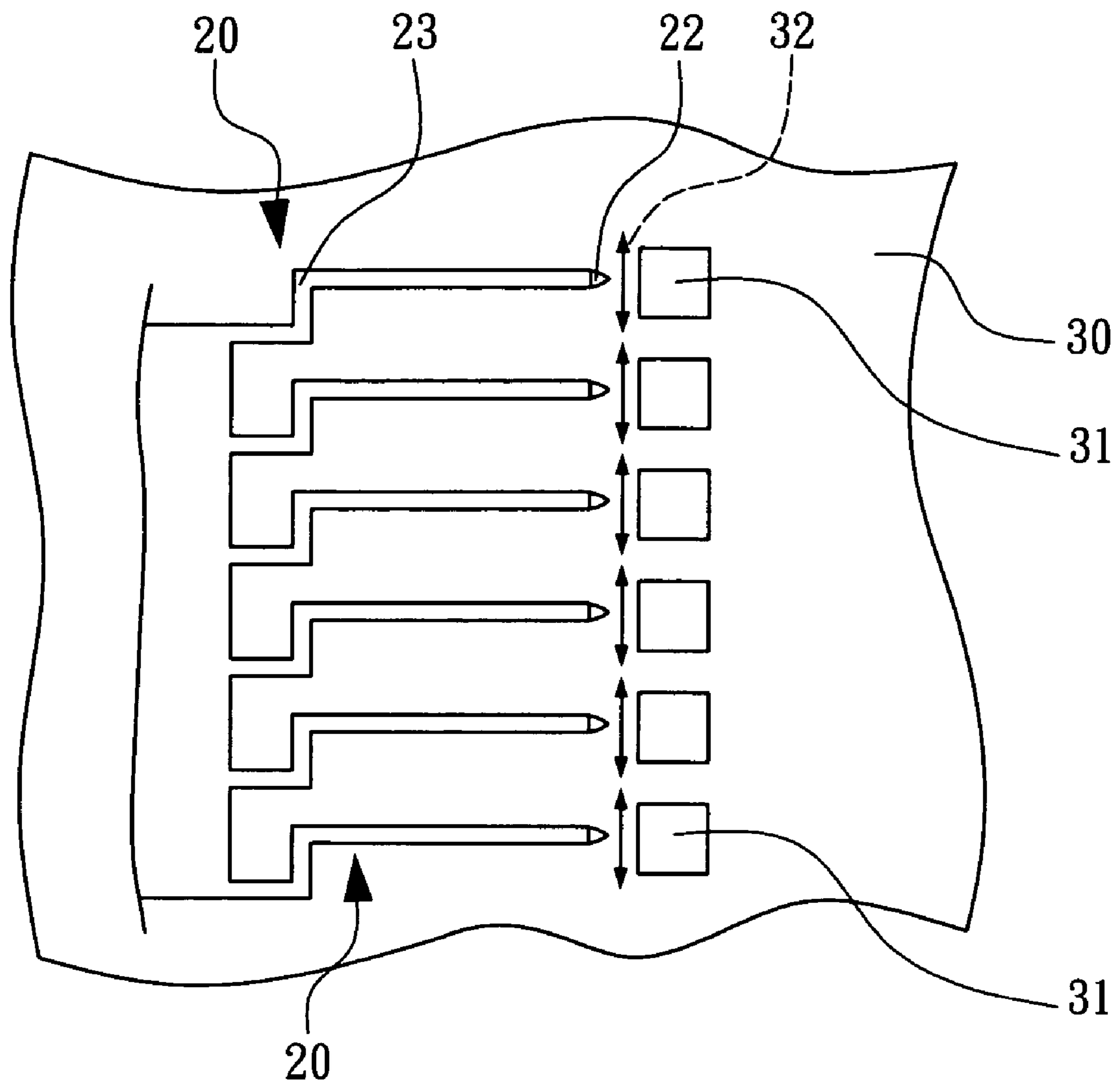
(51) **Int. Cl.**

G01R 3/00 (2006.01)

(52) **U.S. Cl.** **29/884; 29/842; 29/846; 29/874; 324/761; 361/772**

5 Claims, 11 Drawing Sheets





PRIOR ART

FIG. 2

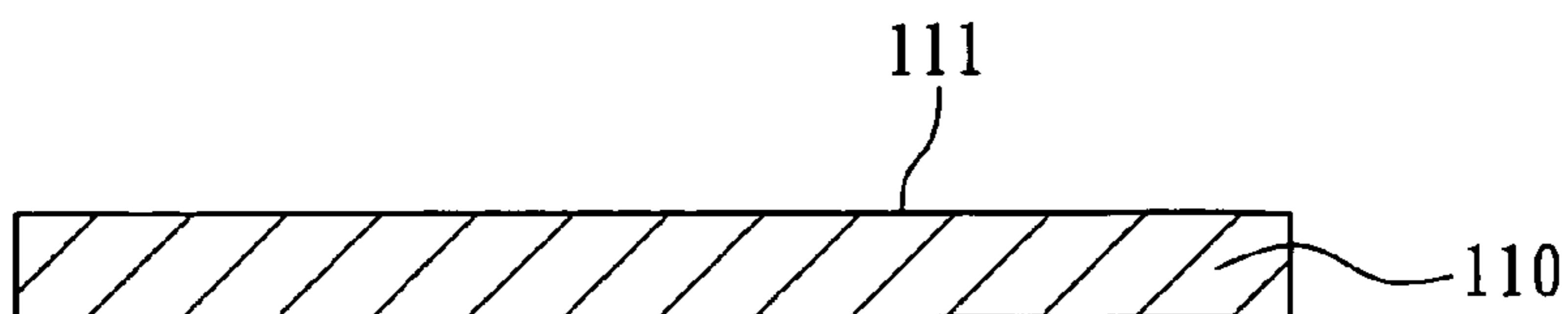


FIG. 3A

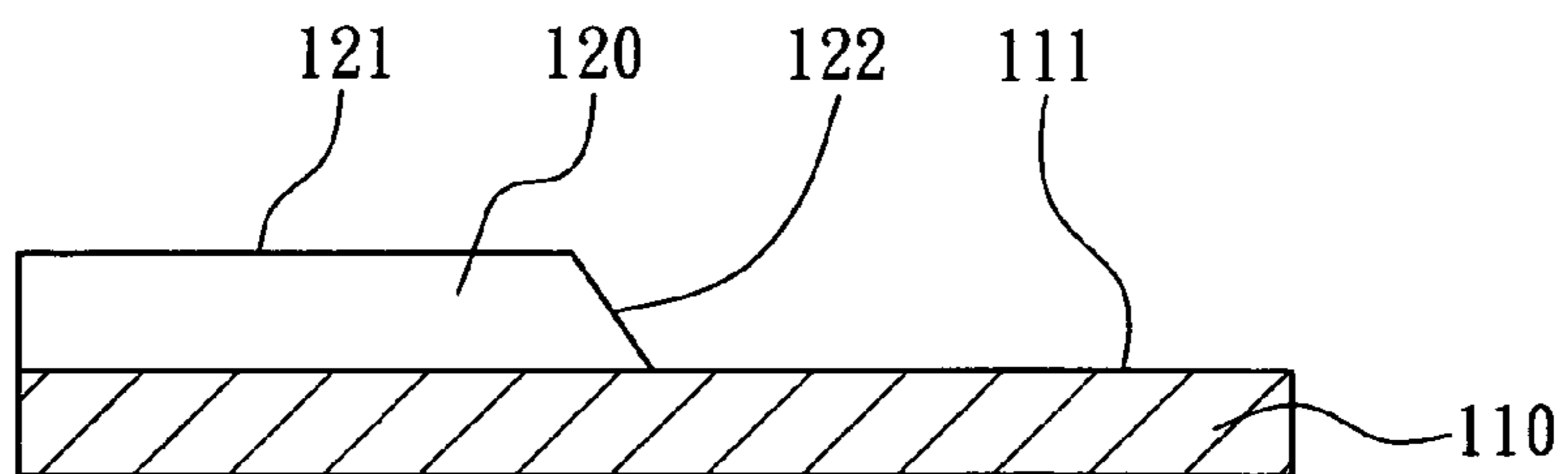


FIG. 3B

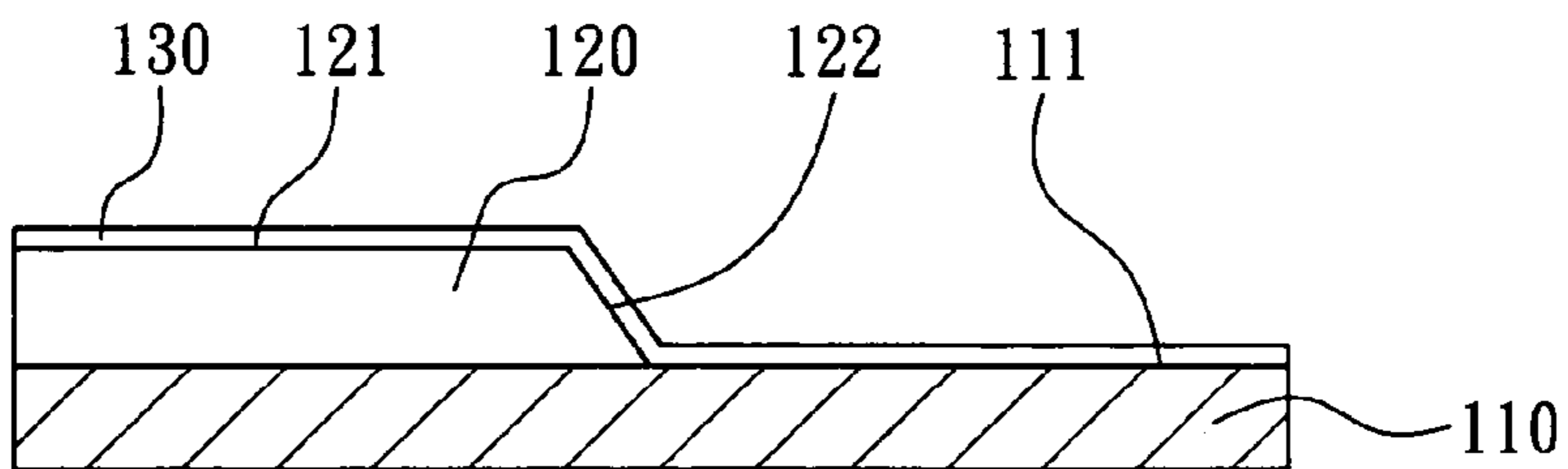


FIG. 3C

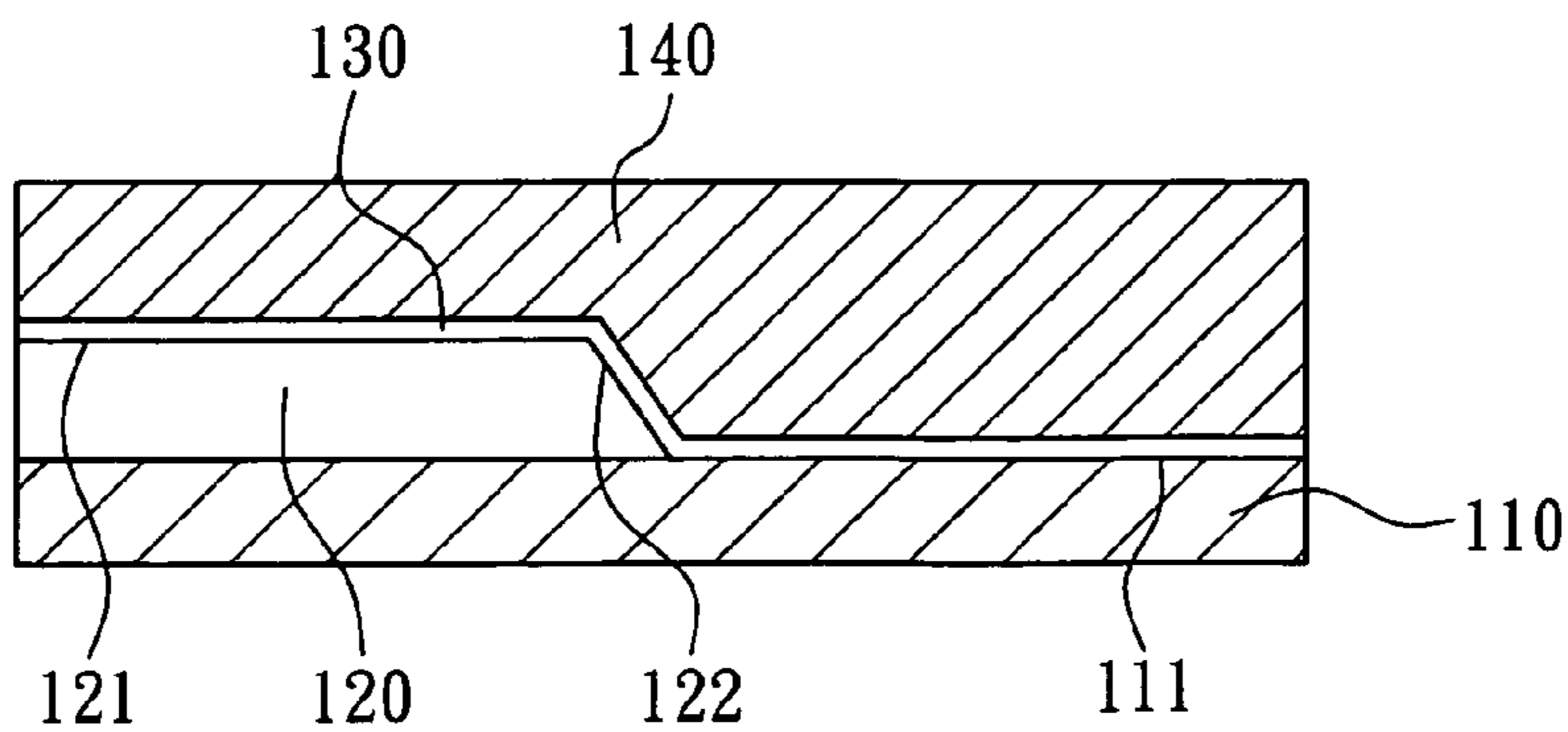


FIG. 3D

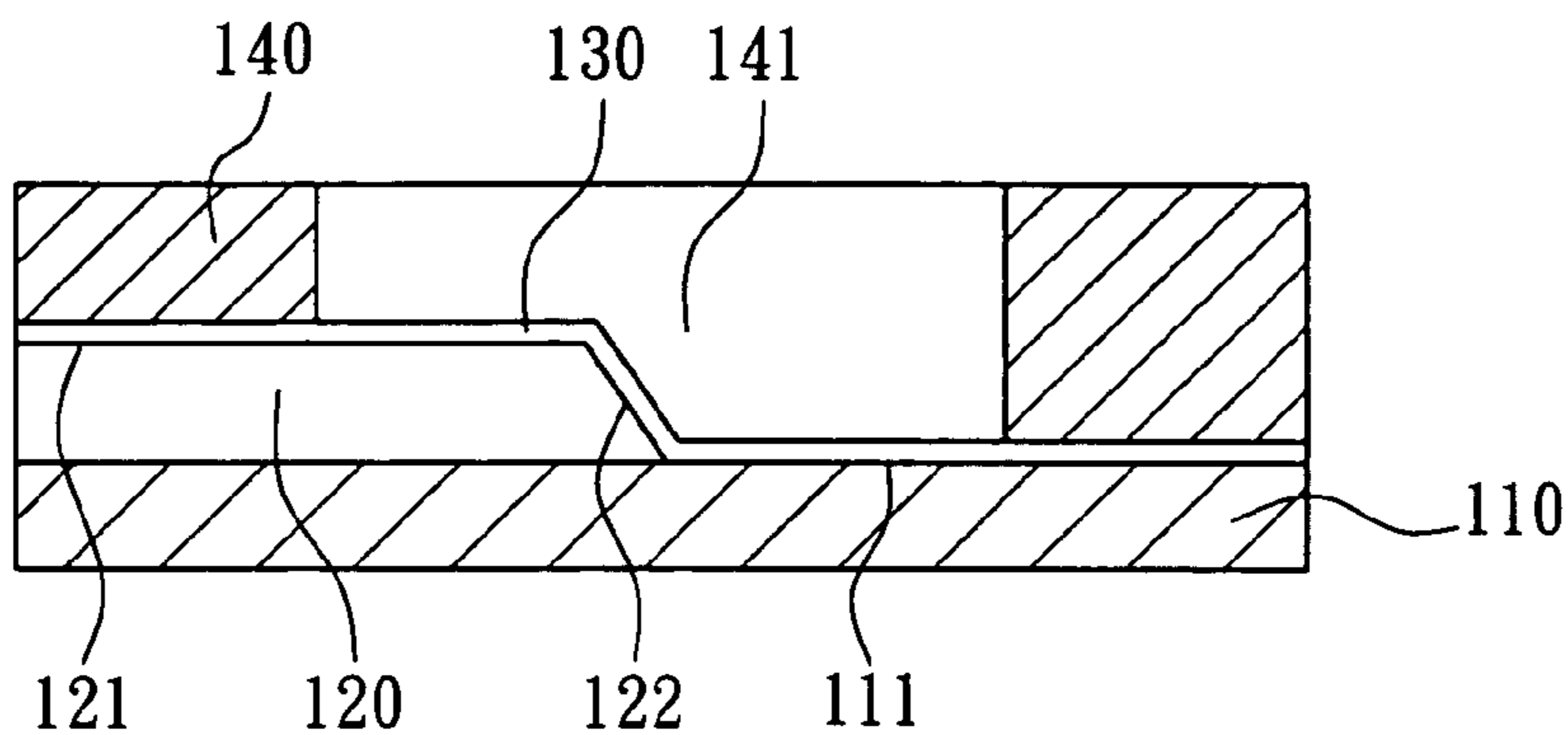


FIG. 3E

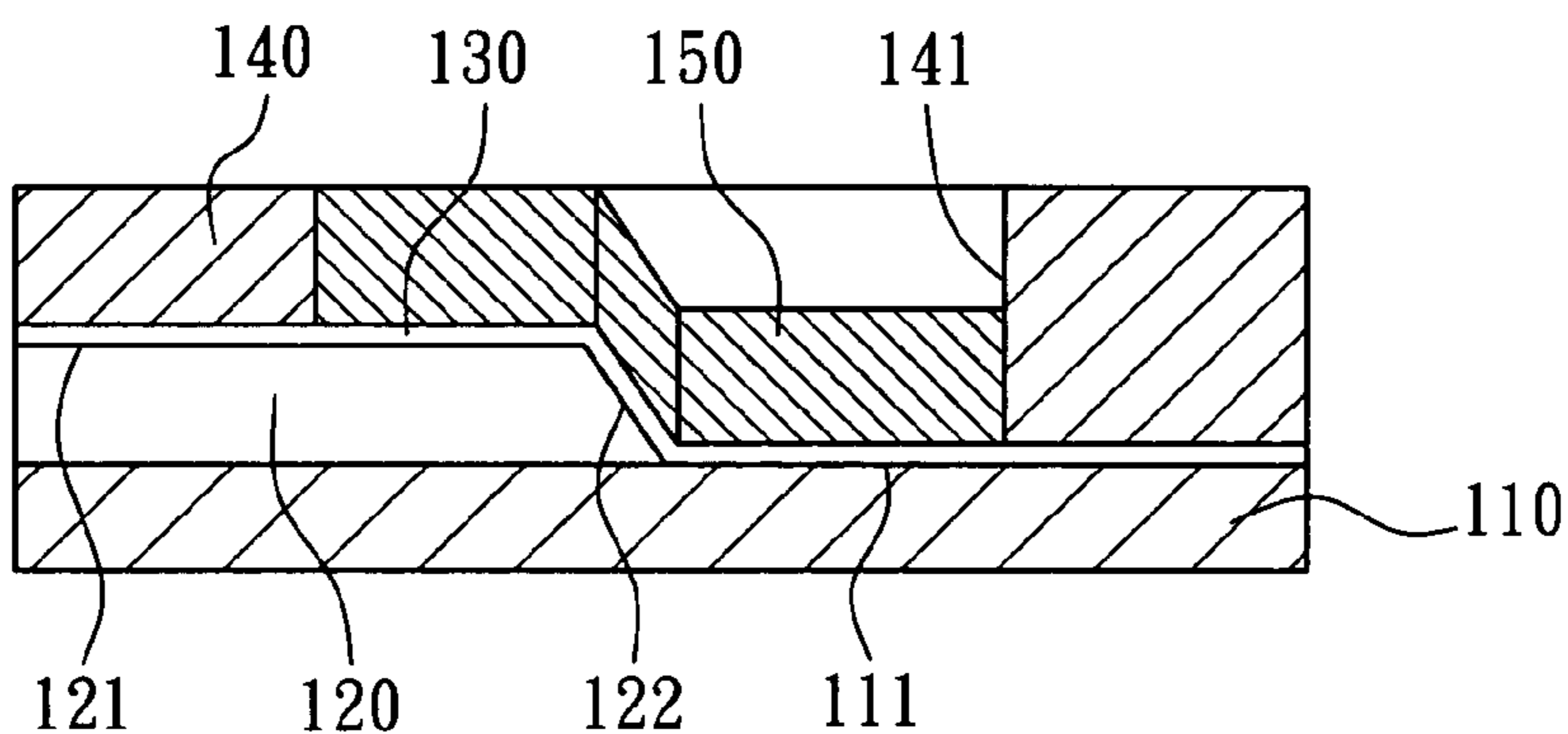


FIG. 3F

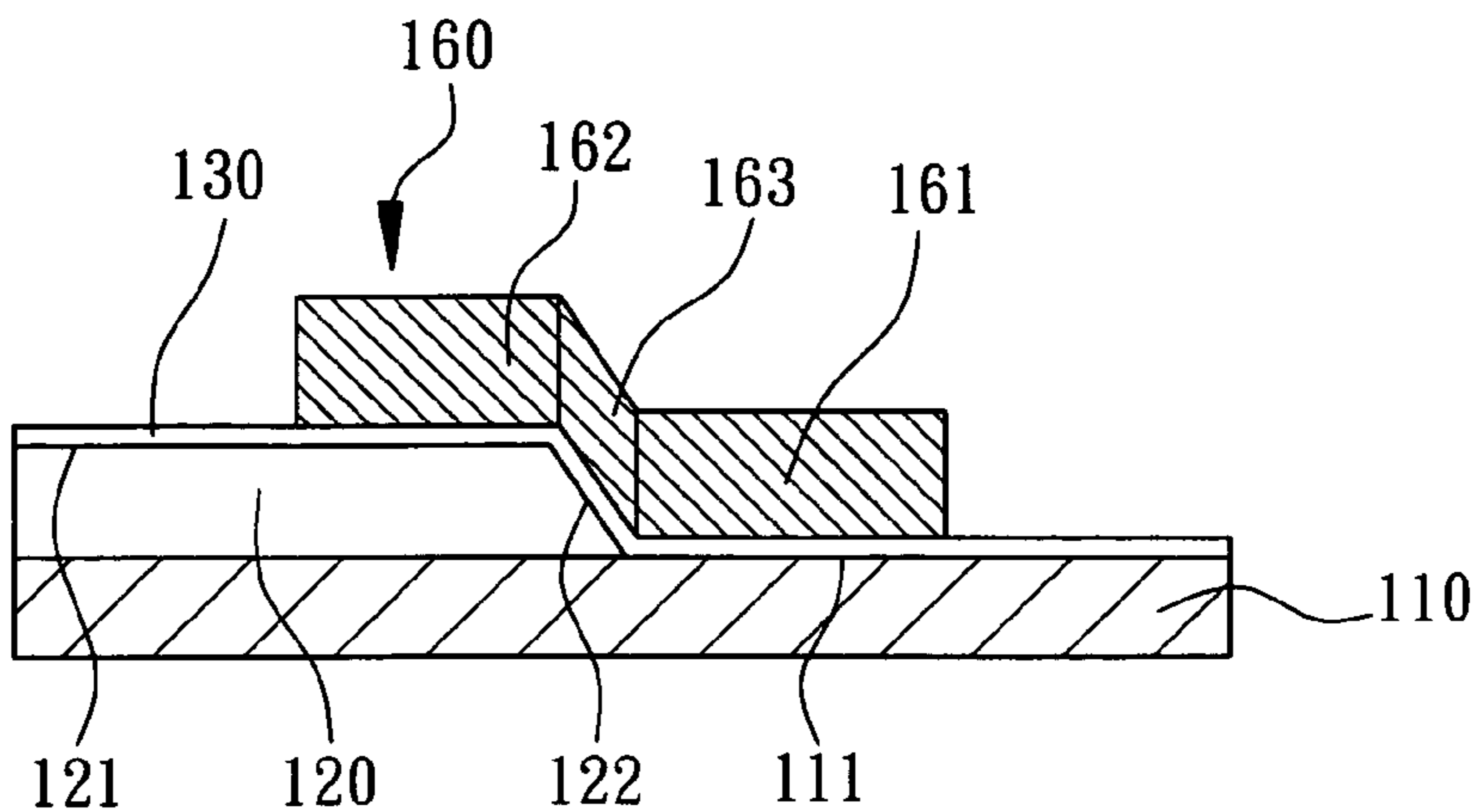
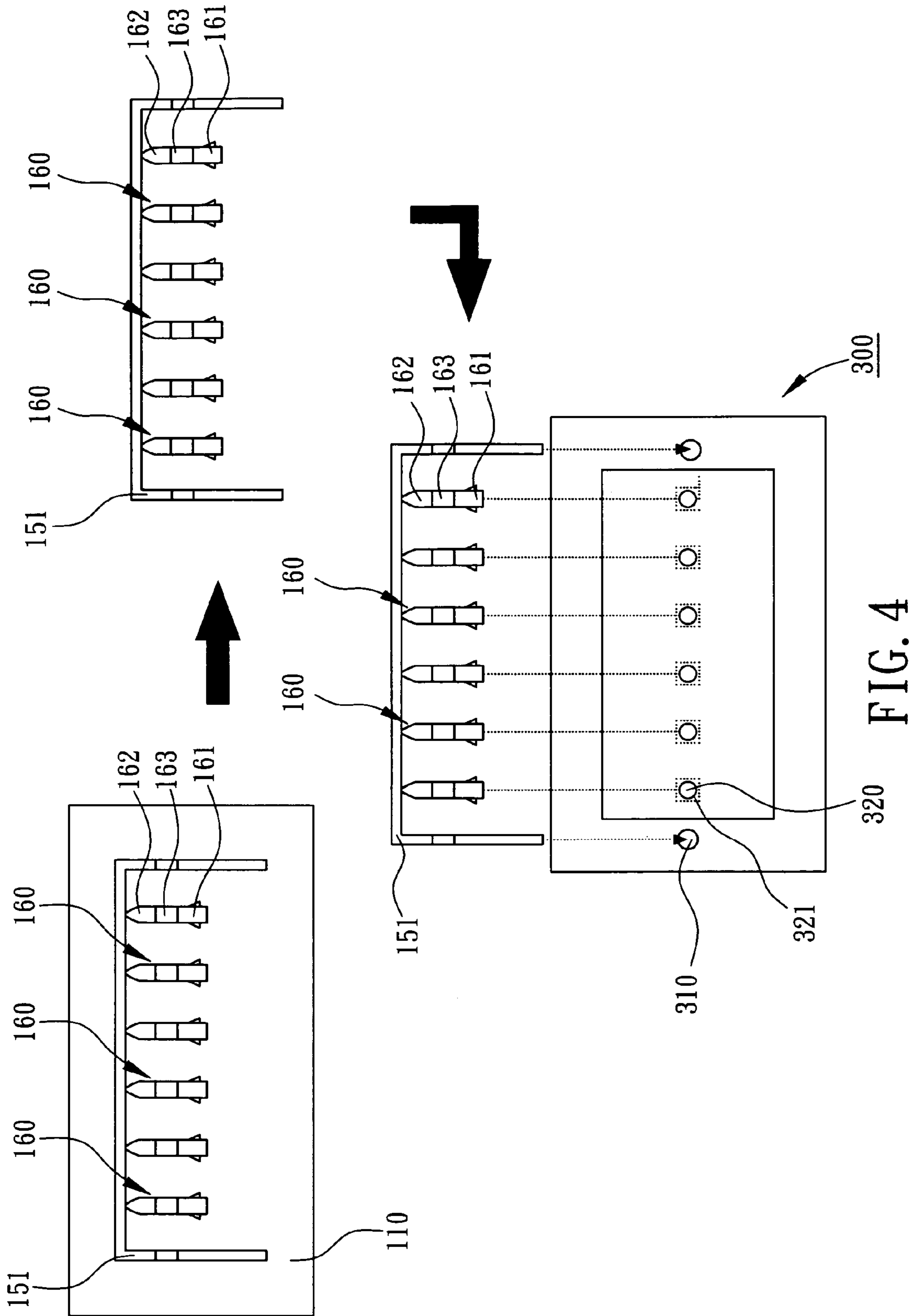


FIG. 3G



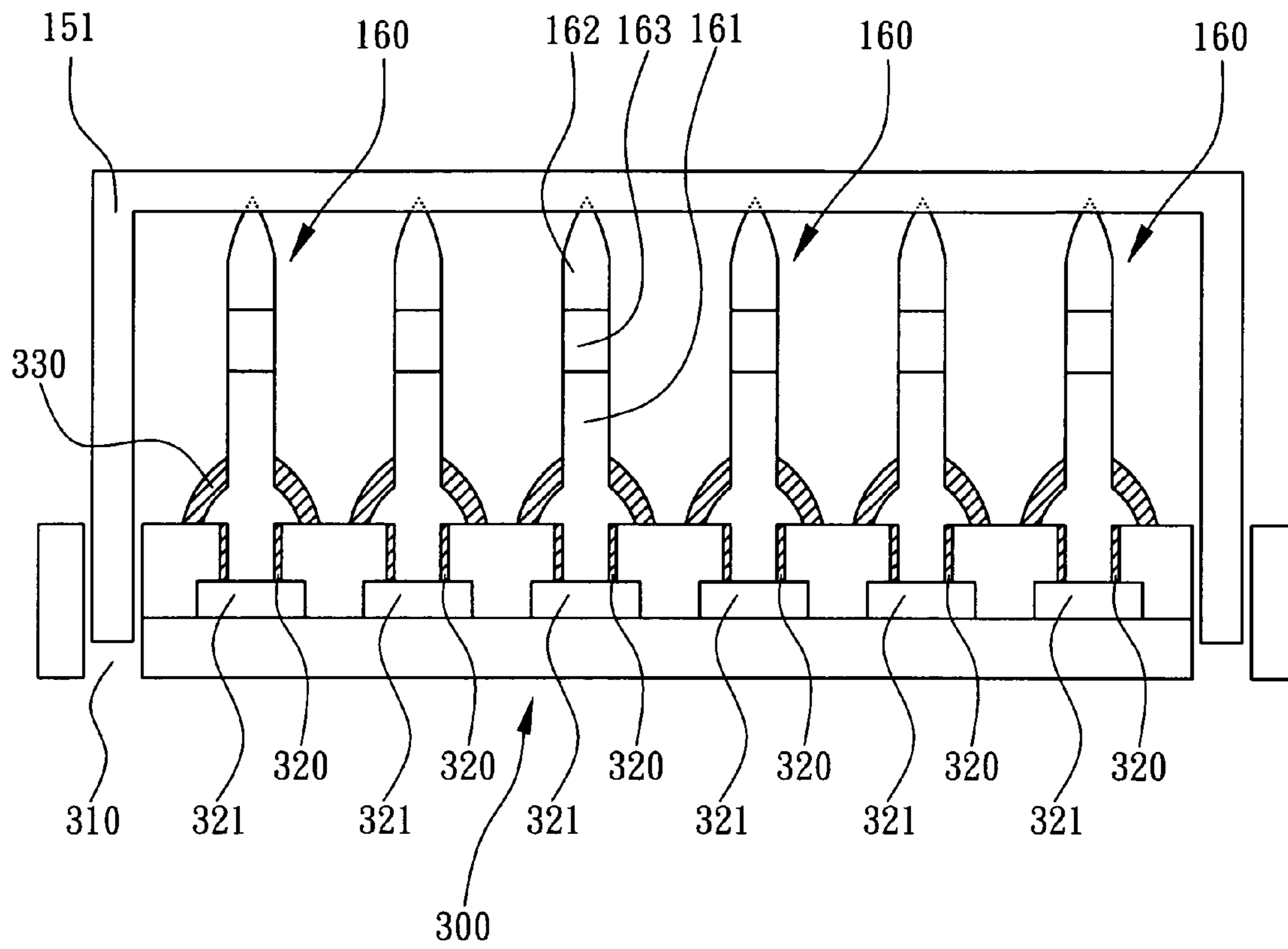


FIG. 5

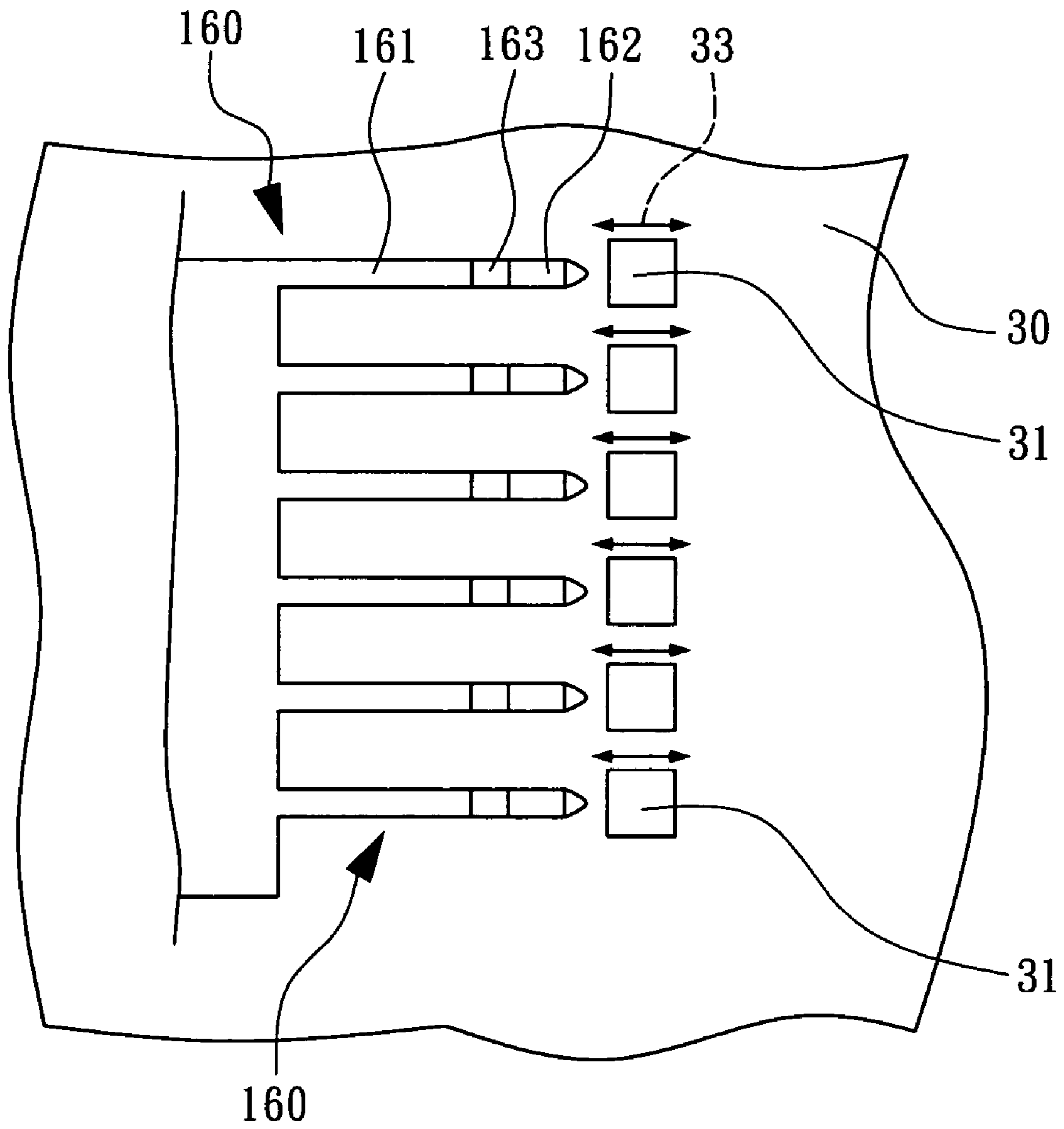


FIG. 6

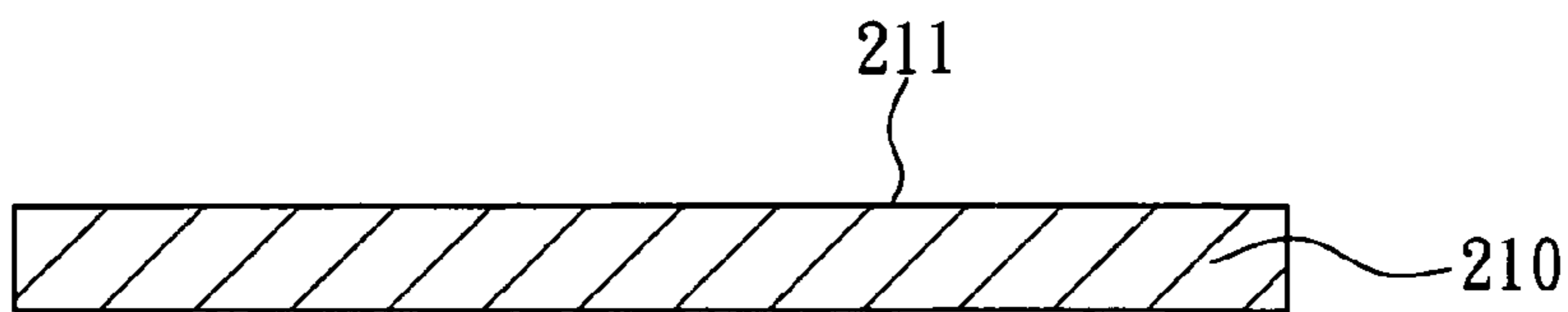


FIG. 7A

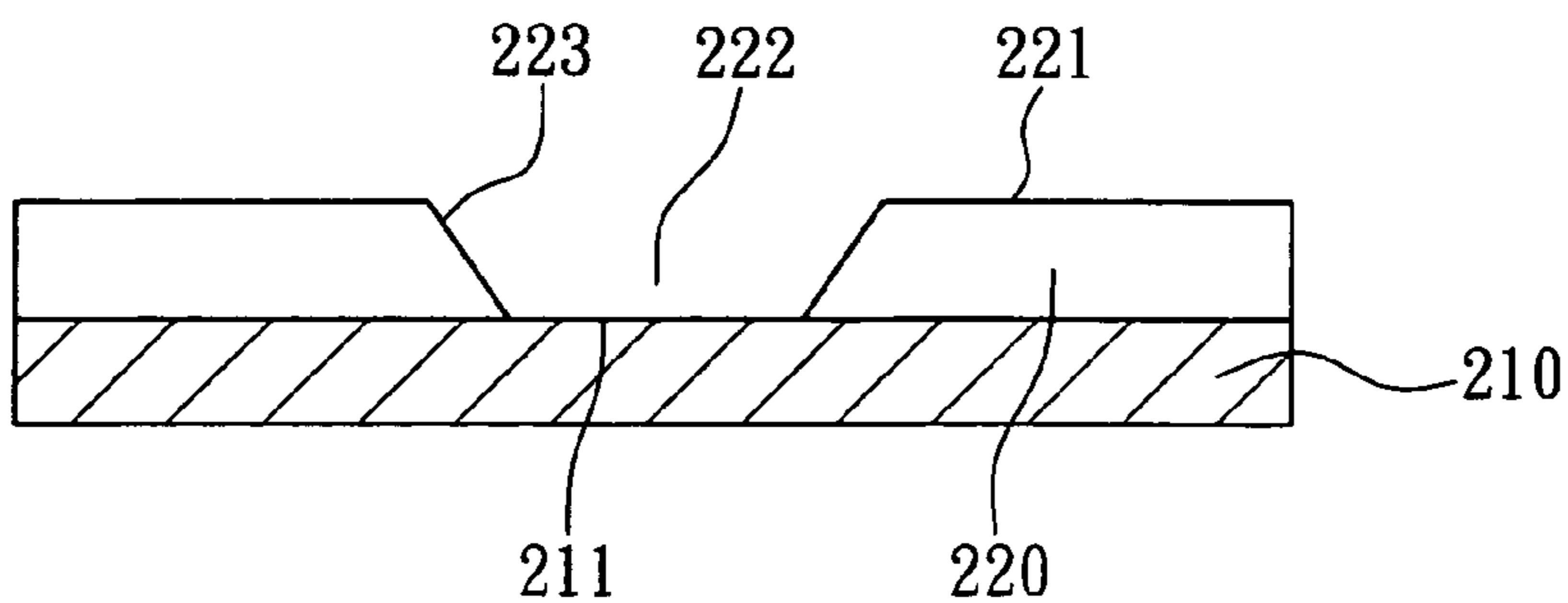


FIG. 7B

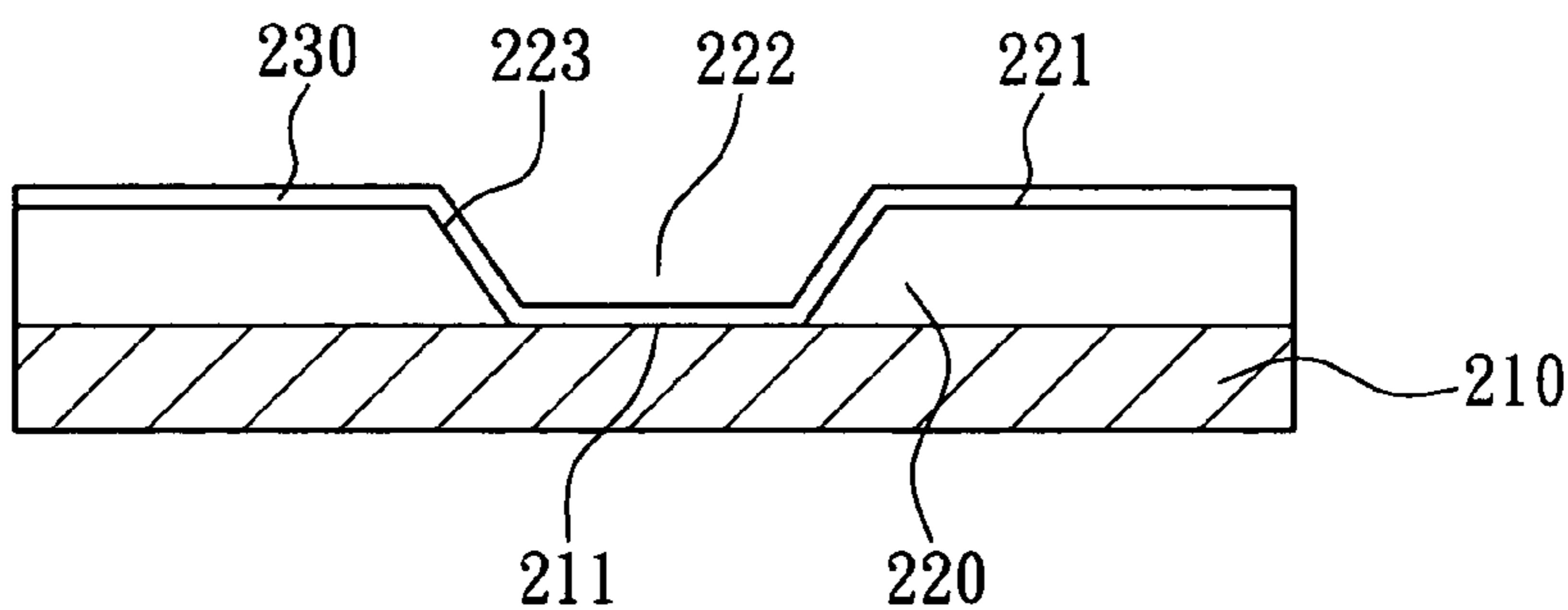


FIG. 7C

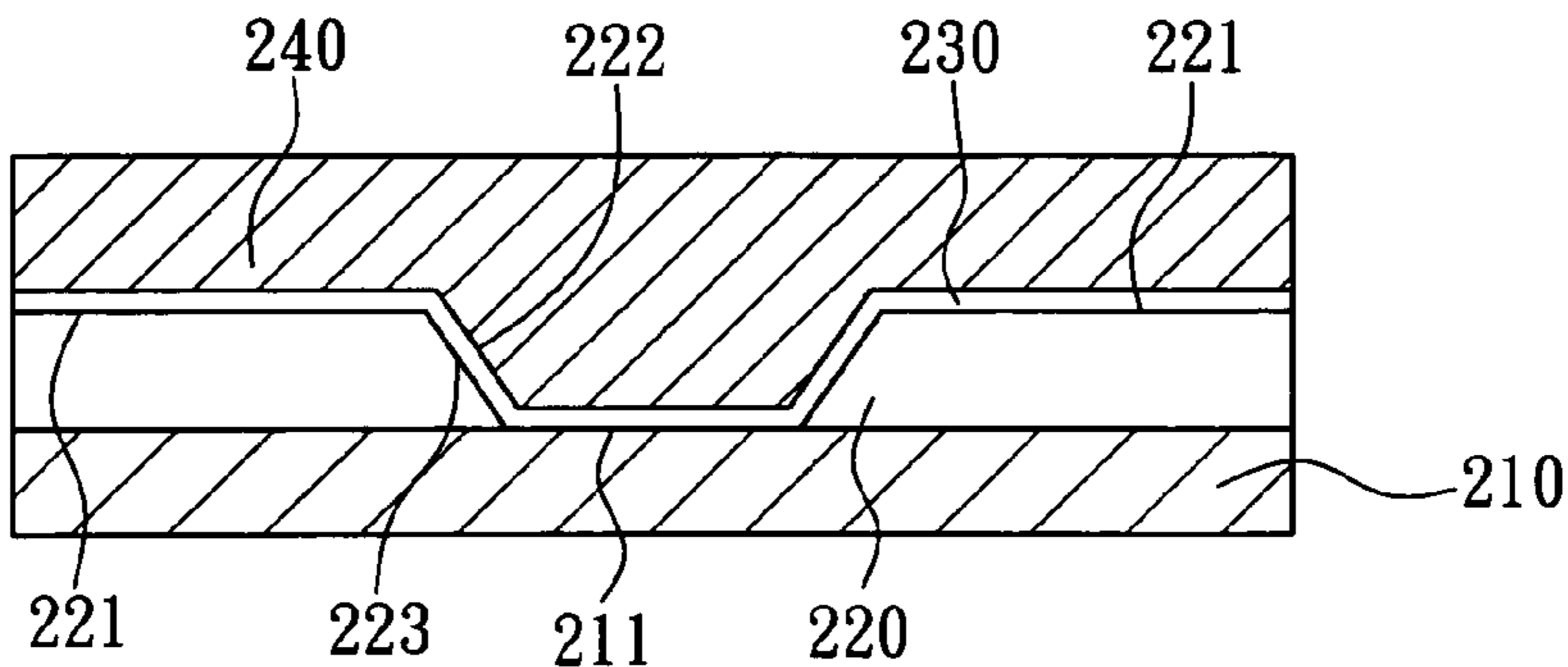


FIG. 7D

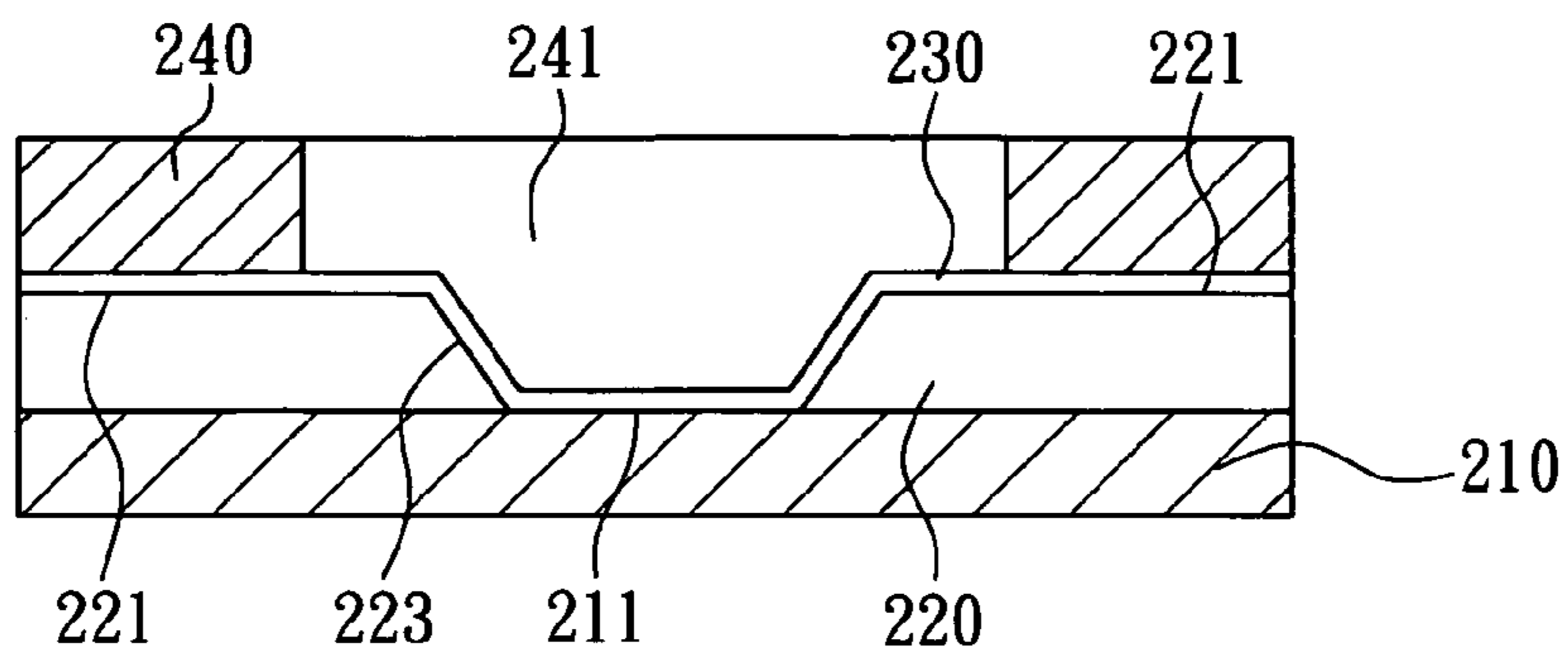


FIG. 7E

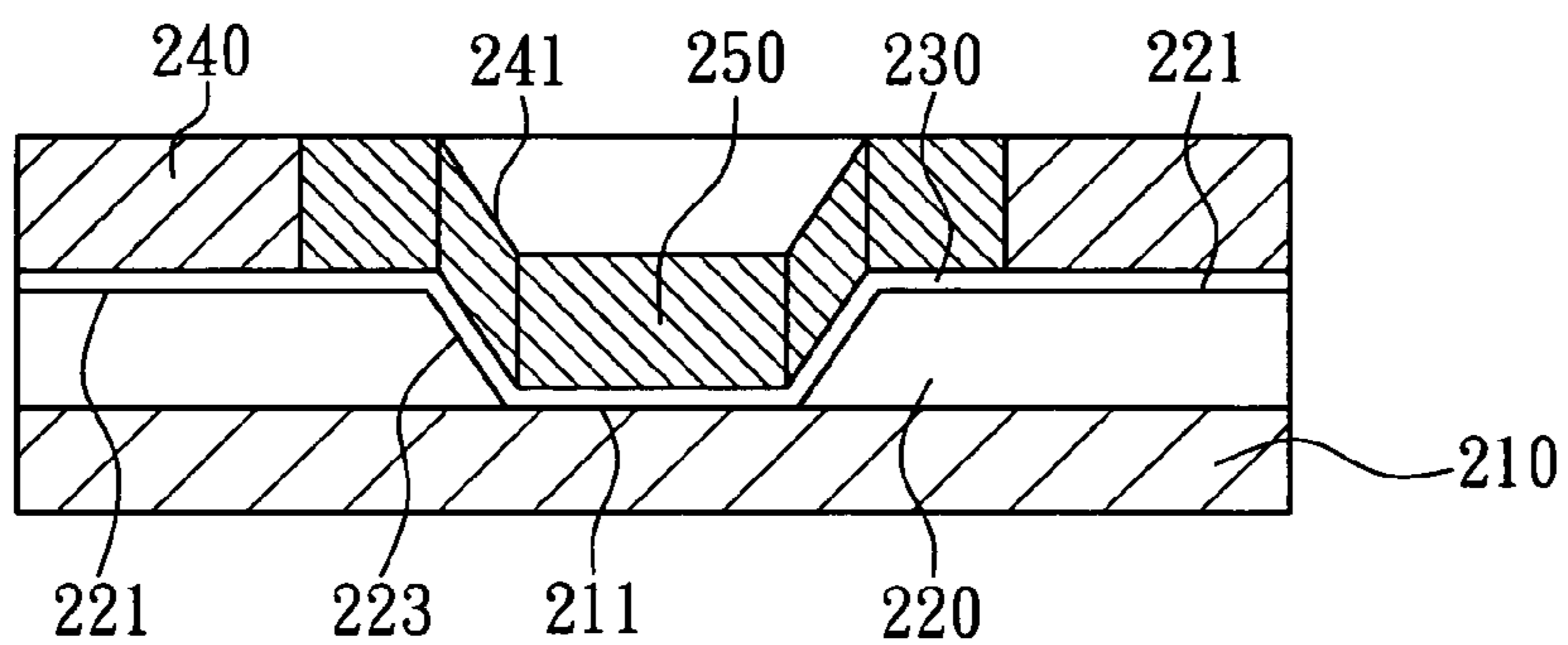


FIG. 7F

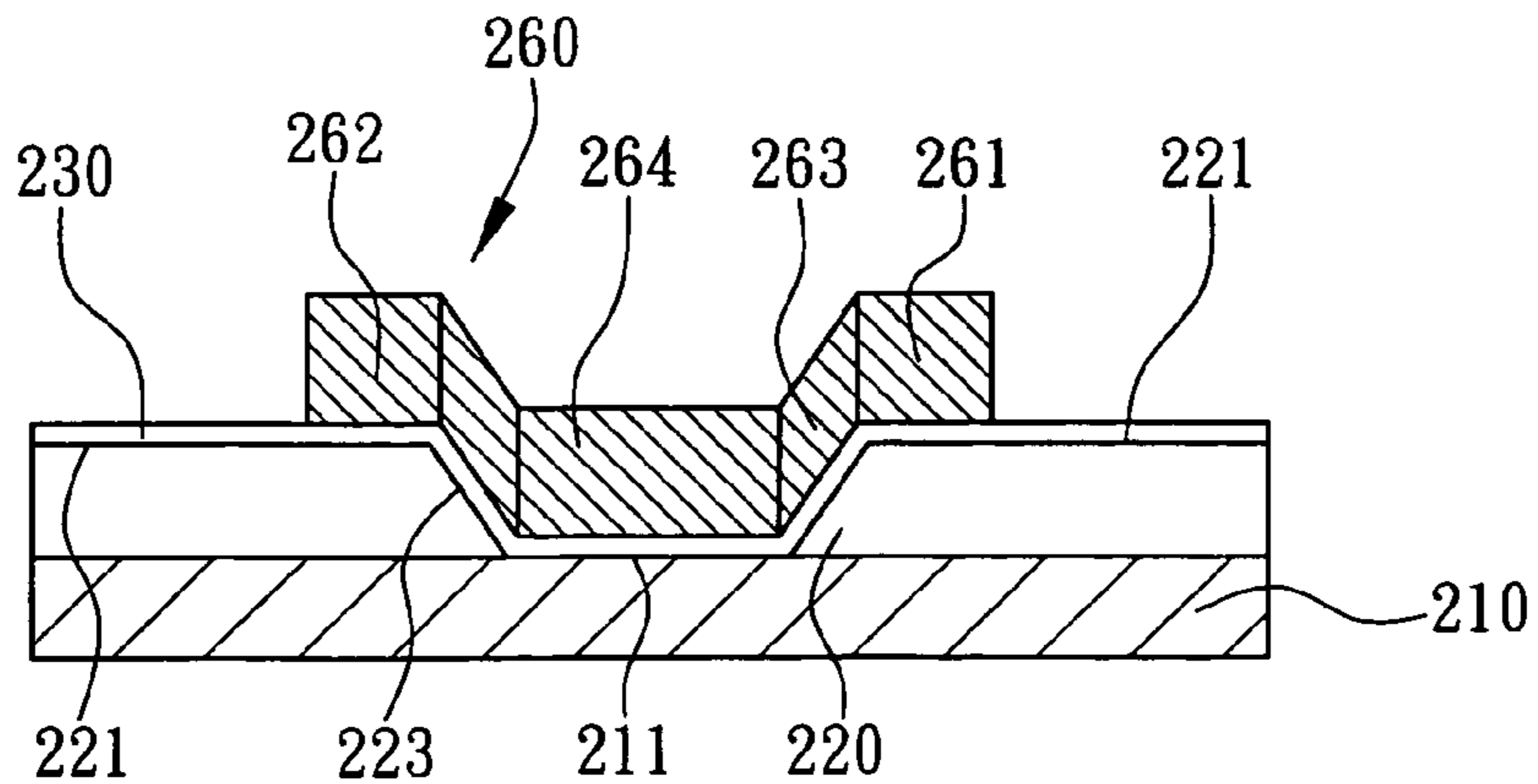


FIG. 7G

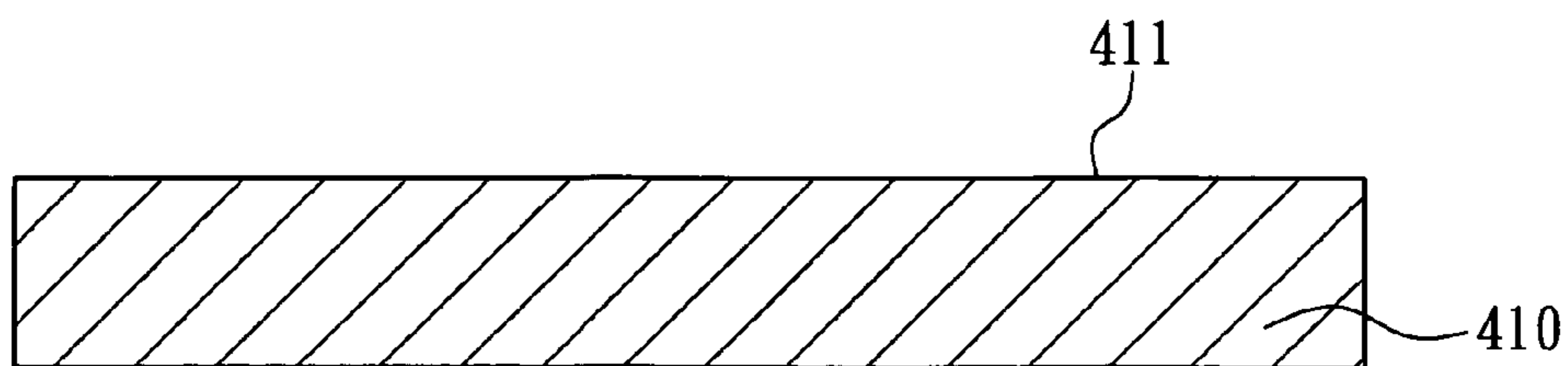


FIG. 8A

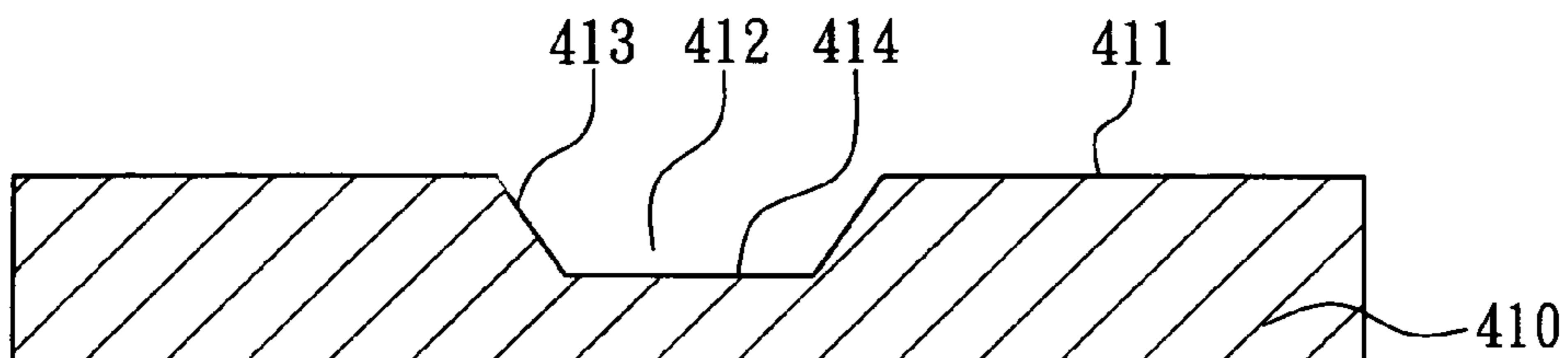


FIG. 8B

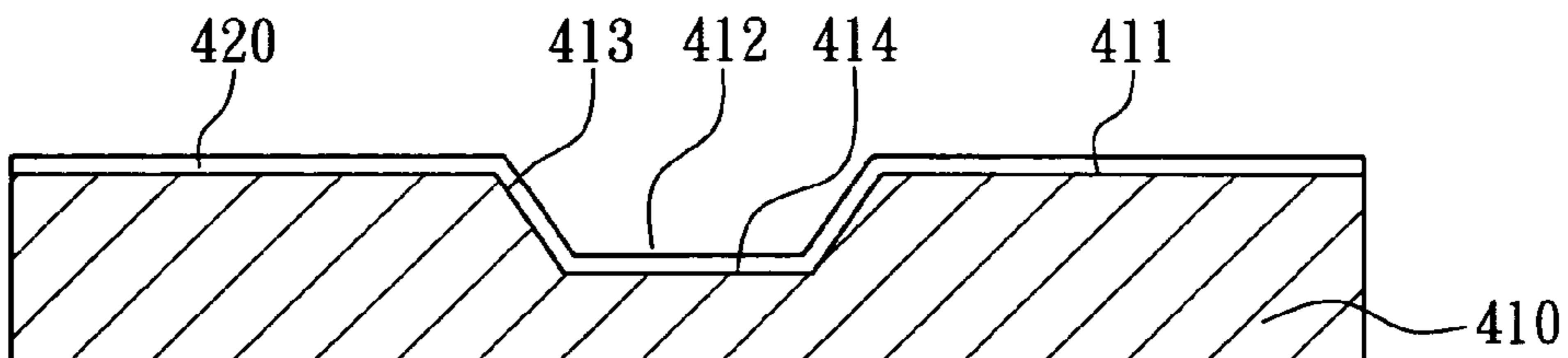


FIG. 8C

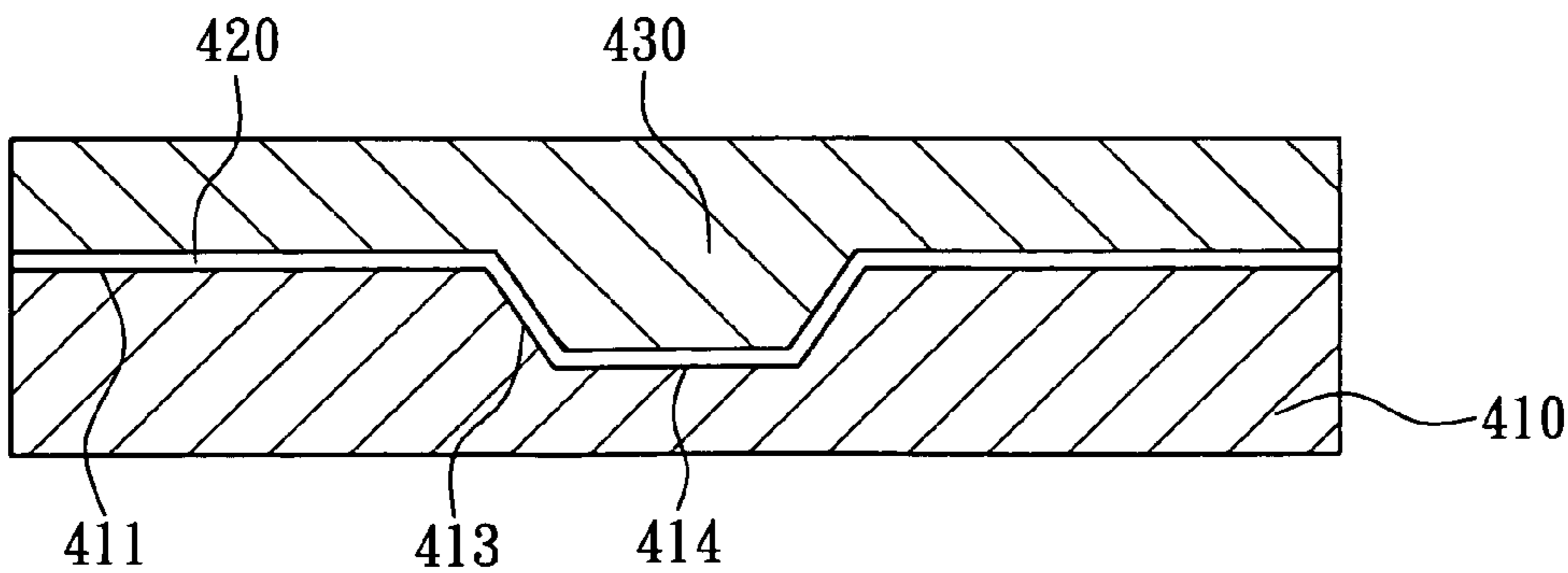


FIG. 8D

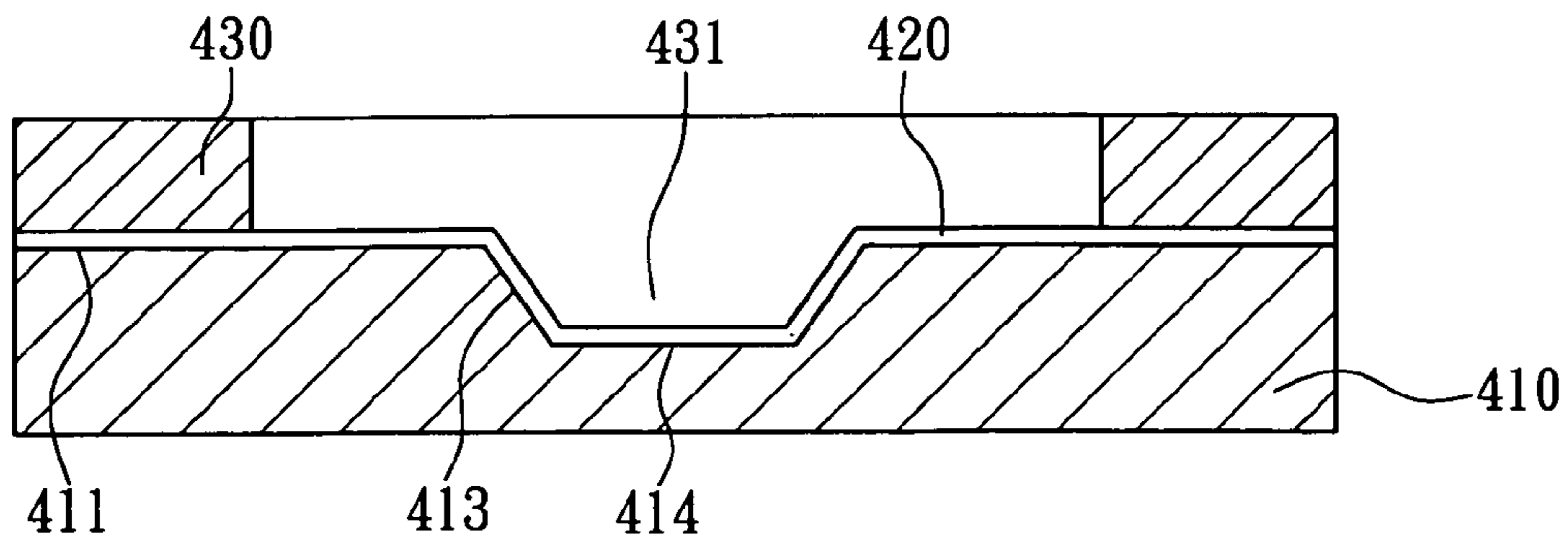


FIG. 8E

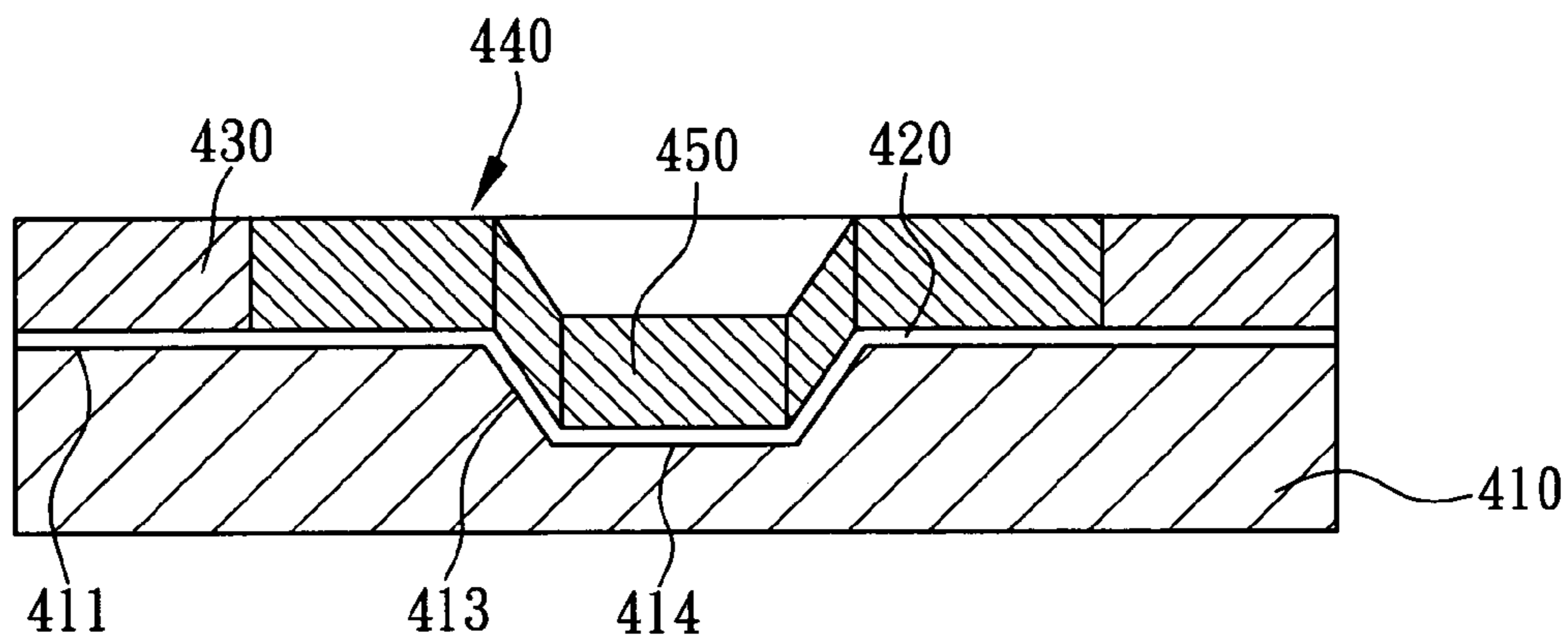


FIG. 8F

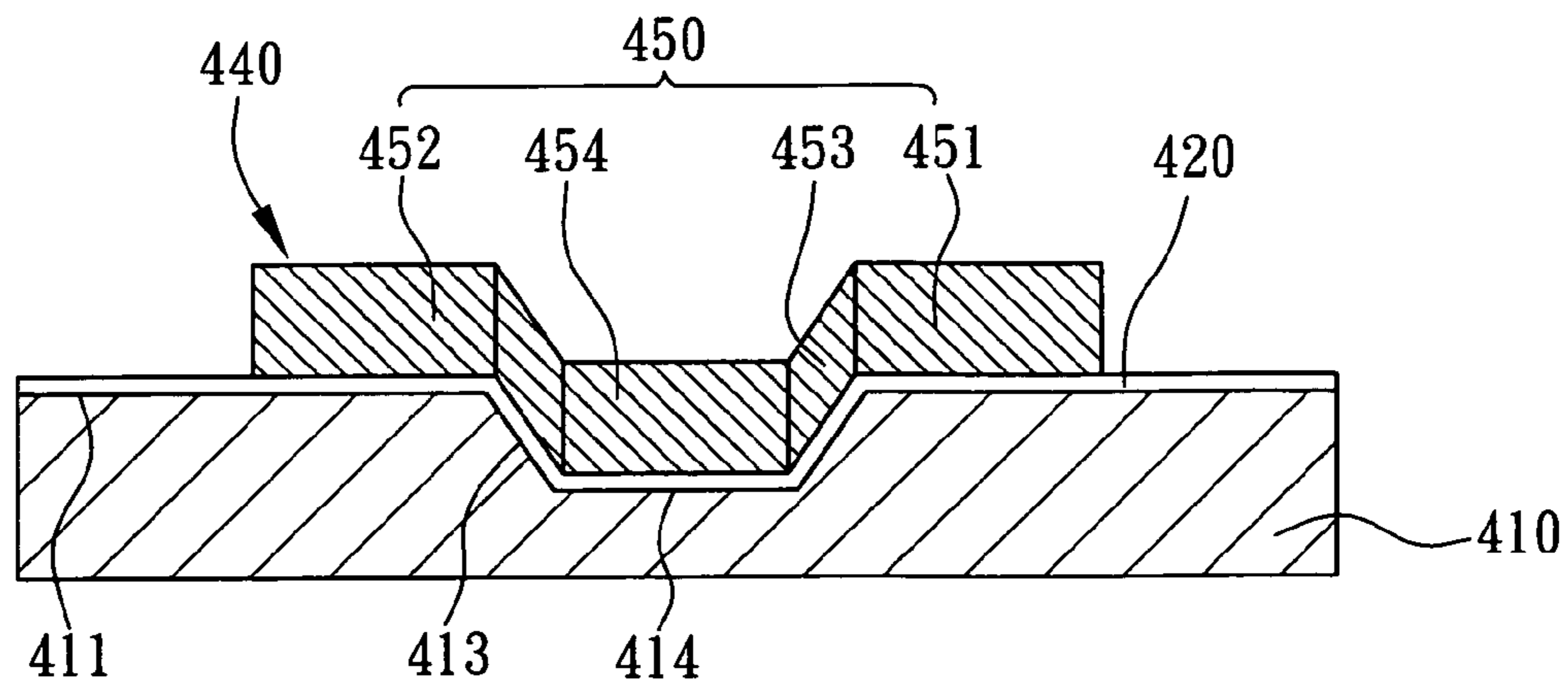


FIG. 8G

1

METHOD FOR FABRICATING A PLURALITY OF ELASTIC PROBES IN A ROW

FIELD OF THE INVENTION

The present invention relates to a method of fabricating a plurality of elastic probes in a row, and more particularly, to a method of fabricating a plurality of elastic probes in a row which can scrub through the oxide layer on the high-density, fine-pitch bonding pads of a semiconductor chip under testing.

BACKGROUND OF THE INVENTION

In a conventional IC tester, a probe card with probes is installed in the test head of a tester. A flexible portion have been specially designed in the probes of a probe card which can scrub through the oxide layer on the bonding pads of an IC chip under test to ensure good electrical contacts. Conventional methods of manufacturing the probes include metal casting, extraction, or pressing, however, a tailor-made tooling is required which is very expensive where the shapes of the probes are very limited. Moreover, as the pitches of the bonding pads become smaller and the densities of the bonding pads become higher, probes manufactured by conventional methods cannot meet the fine-pitch and high-density requirement of the bonding pads.

As revealed in R.O.C. Taiwan Patent publication No. 517320, John et al. discloses a method of manufacturing a plurality of flexible probes in a row using vapor deposition. As shown in FIG. 1, a substrate **10** is provided which has a flat surface **11** where a plurality of probes **20** are formed on the flat surface **11** by sputtering, plating, or chemical-vapor deposition. A connecting bar **21** is connected to the probes **20**. Each probe **20** has a contact point **22** and a flexible portion **23** bent in the horizontal direction along the flat surface **11** of the substrate **10**. The probes **20** are assembled to a probe card.

As shown in FIG. 2, an IC **30** under test has a plurality of bonding pads **31**. During chip probing, the contact points **22** of the probes **20** will contact the bonding pads **31** of the IC **30**. While the contact points **22** of the probes **20** are probing the bonding pads **31**, the flexible portion **23** of the probes **22** due to the overdrives will allow the contact points **22** to shift in the same horizontal direction **32** to penetrate the oxide layer on the bonding pads **31**. However, the penetrating shift direction **32** is parallel to the arranging direction of the bonding pads **31** which cause electrical shorts between the probes **22** and damages to the IC, the probe card or even the tester.

SUMMARY OF THE INVENTION

The main purpose of the present invention is to provide a method for fabricating a plurality of elastic probes in a row where a shaping layer is formed on a flat surface of a substrate to offer another flat surface and a photoresist layer is formed on the shaping layer. The photoresist layer is patterned to form a plurality of slots crossing the interface of the two flat surfaces which partially expose the substrate and the shaping layer for forming the plurality of elastic probes. Therefore, the elastic bending portions of the probes are not parallel to the flat surfaces of the substrate nor the shaping layer where the probes are formed. During chip probing, when the contact points of the probes contact the bonding pads of the chip, the probes due to overdrives will be bent.

2

The penetrating shift direction of the contact points is approximately perpendicular to the arranging direction of the bonding pads which is suitable for probing chips with fine-pitch and high-density bonding pads. Moreover, the probes will not short to each other during chip probing and the probes can easily installed on the probe head to shorten the lead time of manufacturing a probe card.

The second purpose of the present invention is to provide a method for fabricating a plurality of elastic probes in a row where the shaping layer is disposed and patterned on the substrate where an edge slope of the shaping layer is formed as an interface between the two flat surfaces of the substrate and the shaping layer. Accordingly, each of the probes has two end portions on the substrate and/or on the shaping layer and at least a flexible portion therebetween, wherein the flexible portion is formed on the edge slope not parallel to the two end portions. The contacting points and the connecting points of the probes are formed in the two end portions. The edge slope of the shaping layer will determine the shapes of the flexible portions to save the expensive tooling cost of fabricating different shapes of probes.

The third purpose of the present invention is to provide a method for fabricating a plurality of elastic probes in a row where the shaping layer has an edge slope as an interface between the flat surfaces of the substrate and the shaping layer. A photoresist layer is formed on the flat surfaces of the substrate and the shaping layer. The photoresist layer is then patterned to form a plurality of slots crossing the edge slope to partially expose the flat surfaces of the substrate and the shaping layer for forming a plurality of elastic probes in a row. Therefore, the elastic bending portions of the probes are not parallel to the flat surfaces of the substrate nor the shaping layer. During chip probing, the penetrating shift direction of the contact points of the probes due to overdrives are approximately perpendicular to the arranging direction of the bonding pads on the IC chip without causing shorts between the elastic probes which are capable of probing a chip with fine-pitch and high-density bonding pads. Moreover, the probes are installed or replaced on a probe head row by row to shorten the lead time of manufacturing a probe card.

The fourth purpose of the present invention is to provide a method for fabricating a plurality of elastic probes in a row where a substrate is provided. A recess is formed in the substrate to have a bottom and a plurality of inner sides to form the elastic bending portions of the elastic probes. The elastic probes have contact portions, connecting portions formed on the flat surface of the substrate and middle portions formed on the bottom. The elastic bending portions are formed on the inner sides of the recess. The shapes of the elastic bending portions are determined by the recess to save the tooling cost for fabricating different shapes of probes.

The fifth purpose of the present invention is to provide a probe pin assembly having a plurality of elastic probes in a row where each of the elastic probes has a first end portion, at least an elastic bending portion, and a second end portion. The first end portions and the second end portions are connected by the corresponding elastic bending portions. All of the first end portions and all of the second end portions are formed on two flat planes which are parallel or coplanar. Moreover, the elastic bending portions are not parallel to the two flat planes. Therefore, when probing high-density and fine-pitch bonding pads of a chip, probes will swift without cause shorts between the probes.

According to the present invention, a method for fabricating a plurality of elastic probes in a row is revealed where each of the elastic probes has a first end portion, a second

end portion, and at least an elastic bending portion connecting the first end portion and the second end portion. A substrate is provided, and a shaping layer is formed on a first flat surface of the substrate to offer a second flat surface, where an interface is formed between the exposed first flat surface and the second flat surface. Then, a photoresist layer is formed on the shaping layer and on the substrate. Then, the photoresist layer is patterned to form a plurality of slots crossing the interface to partially expose the substrate and the shaping layer for forming the elastic probes. Finally, a probe metal layer is formed in the slots so that the first end portions of the elastic probes are formed on the first flat surface of the substrate, the second end portions on the second flat surface of the shaping layer, and the elastic bending portions are formed on the interface.

DESCRIPTION OF THE DRAWINGS

FIG. 1 is a three-dimensional view of a conventional probe pin assembly having elastic probes fabricated on a substrate.

FIG. 2 shows the penetrating shift direction of the elastic probes when probing an untested IC chip.

FIGS. 3A to 3G are the cross sectional views of a substrate during fabrication processes of a probe pin assembly having elastic probes according to the first embodiment of the present invention.

FIG. 4 shows the probe pin assembly when connecting to a probe head according to the first embodiment of the present invention.

FIG. 5 is the cross sectional view of the probe pin assembly placed on the probe head according to the first embodiment of the present invention.

FIG. 6 shows the penetrating shift direction of the elastic probes when probing an untested IC chip according to the first embodiment of the present invention.

FIGS. 7A to 7G are the cross sectional views of a substrate during fabrication processes of a probe pin assembly having elastic probes according to the second embodiment of the present invention.

FIGS. 8A to 8G are the cross sectional views of a substrate during fabrication processes of a probe pin assembly having elastic probes according to the third embodiment of the present invention.

DETAIL DESCRIPTION OF THE INVENTION

Please refer to the attached drawings, the present invention will be described by means of embodiment(s) below.

In the first embodiment according to present invention, a method for fabricating a plurality of elastic probes in a row is disclosed as shown in FIG. 3A to 3G. Firstly, as shown in FIG. 3A, a substrate **110** is provided, where the substrate **110** is a semiconductor substrate having a first flat surface **111**. As shown in FIG. 3B, a shaping layer **120** is formed on the first flat surface **111** of the substrate **110**, where at least a portion of the first flat surface **111** is still exposed. The material of the shaping layer **120** may selected from photoresist or the other material easy to pattern. The shaping layer **120** has a second flat surface **121** higher than and parallel to the first flat surface **111**. In this embodiment, the shaping layer **120** further has an edge slope **122** as an interface between the first flat surface **111** and the second flat surface **121**. Therein, the included angle between the first flat surface **111** of the substrate **110** and the edge slope **122** ranges from 20 to 80 degrees and the thickness of the shaping layer **120** ranges from 2 to 100 micrometers. As

shown in FIG. 3C, preferably, a release layer **130** is formed on the first flat surface **111** of the substrate **110** and on the second flat surface **121** and the edge slope **122** of the shaping layer **120**. In this embodiment, the release layer **130** contains titanium formed by metal sputtering.

As shown in FIG. 3D, a photoresist layer **140** is formed on the release layer **130** above the first flat surface **111**, the second flat surface **121** and the edge slope **122**. The thickness of the photoresist layer **140** may be thicker than the shaping layer **120**. As shown in FIG. 3E, the photoresist layer **140** is patterned to form a plurality of slots **141** by photolithography. The slots **141** are configured for forming the plurality of elastic probes, wherein the slots **141** cross the edge slope **122** from the first flat surface **111** to the second flat surface **121**.

As shown in FIG. 3F, a probe metal layer **150** is formed in the slot **141** by electroplating or electroless-plating. Please refer to FIGS. 3G and 4, the probe metal layer **150** includes a plurality of elastic probes **160**. The thickness of the probe metal layer **150** can be increased to enhance the mechanical strength of the probes. Preferably, the probe metal layer **151** is a multi-layer structure by plating, which includes at least an elastic support layer, a conductive layer, and an anti-adhesive metal layer (not shown in the figures). For example, the elastic support layer can be made of nickel or nickel-cobalt, the conductivity metal is made of gold and formed on the elastic support layer for high speed and high frequency testing, the anti-adhesive metal layer is made of palladium and formed on the conductivity metal.

As shown in FIG. 3G, the photoresist layer **140** is stripped and the release layer **130** is also etched so that the elastic probes **160** can separate from the substrate **110** and the shaping layer **120**. Each of the elastic probes **160** has a first end portion **161**, a second end portion **162**, and at least an elastic bending portion **163** connecting the first end portion **161** and the second end portion **162**.

As shown in FIGS. 3F, 3G, and 4, at least a portion of the probe metal layer **150** lying on the first flat surface **111** of the substrate **110** includes the first end portions **161** of the elastic probes **160**. At least a portion of the probe metal layer **150** lying on the second flat surface **121** of the shaping layer **120** includes the second end portions **162** of the elastic probes **160**. At least a portion of the probe metal layer **150** lying on the edge slope **122** includes the elastic bending portions **163** of the elastic probes **160**. Accordingly, all of the first end portions **161** and all of the second end portions **162** are formed on two different planes in parallel. In this embodiment, the first end portions **161** of the elastic probe **160** are used as connecting ends and the second end portions **162** of the elastic probe **160** are used as contacting ends. Preferably, the slots **141** are connected together such that the probe metal layer **150** further comprises a connecting bar **151** integrally connecting to the elastic probes **160** (as shown in FIG. 4). In this embodiment, the connecting bar **151** is connected to the contacting ends (one ends of the second end portion **162**).

As shown in FIGS. 4 and 5, a probe head **300** has a plurality of alignment holes **310**, a plurality of connecting holes **320**, and a plurality of probe pads **321**. Both ends of the connecting bar **151** are inserted into the alignment holes **310** of the probe head **300**. Thereby, the first end portions **161** of the elastic probes **160** are aligned with the probe pads **321** in the connecting holes **320** of the probe head **300**. Solder **330** electrically connect the elastic probes **160** and the probe pads **321**. Then, the connecting bar **151** is separated from the probe contacting ends (one ends of the second

end portions 162) of the elastic probes 160 by metal etching or by mechanical breaking for probing IC.

As shown in FIG. 6, during chip probing, an IC 30 under test has a plurality of bonding pads 31 (or testing pads). The second end portions 162 of the elastic probes 160 have contacting ends to probe the bonding pads 31 of the IC 30. The penetrating shifting direction 33 of the elastic probes 160 due to overdrives will be approximately perpendicular to the arranging direction of the bonding pads 31 of the IC 30 (the arranging direction of the elastic probes 160) so that the bonding pads 31 will be short together. It is suitable for probing IC chips with fine-pitch and high-density bonding pads.

In the second embodiment of the present inventions, another method for fabricating a plurality of elastic probes in a row is shown from FIGS. 7A to 7G. As shown in FIG. 7A, firstly, a substrate 210 is provided, which has a first flat surface 211. As shown in FIG. 7B, a shaping layer 220 is formed on the first flat surface 211 of the substrate 210 where the shaping layer 220 has a second flat surface 221 and a recess 222 to expose at least a portion of the first flat surface 211. In this embodiment, the depth of the recess 222 ranges from 2 to 100 micrometers. The photoresist layer 220 further has a plurality of edge slopes 223 in the recess 222 between the exposed first flat surface 211 and the second flat surface 221. Therein, the included angle between the edge slopes 223 and the covered first flat surface 211 of the substrate 210 ranges from 20 to 80 degrees. As shown in FIG. 7C, preferably, a release layer 230 is formed on the first flat surface 211 of the substrate 210, the second flat surface 221, and the edge slopes 223 of the shaping layer 220 by means of metal sputtering. In this embodiment, the release layer 230 contains titanium and also can be used as a plating seed layer.

As shown in FIG. 7D, a photoresist layer 240 is formed on the release layer 230 and located above the first flat surface 211, the second flat surface 221, and the edge slopes 223. The thickness of the photoresist layer 240 is thicker than the shaping layer 220. As shown in FIG. 7E, the photoresist layer 240 is patterned to form a plurality of slots 241 by photolithography where the slots 241 cross the edge slopes 223.

As shown in FIG. 7F, a probe metal layer 250 is disposed in the slots 241 to form a plurality of elastic probes 260 in a row where the probe metal layer 250 is chosen from a group of conductive metals such as nickel, cobalt, tungsten, gold, palladium, copper, iron, alloy 42 or copper alloy. As shown in FIG. 7G, the photoresist layer 240 is stripped so that the plurality of elastic probes 260 can easily separate from the substrate 210 and the shaping layer 220. Each of the elastic probes 260 has a first end portion 261, a second end portion 262, a plurality of elastic bending portions 263, and a middle portion 264. Referring to FIGS. 7F and 7G, at least a portion of the probe metal layer 250 on the second flat surface 221 of the shaping layer 220 includes the first end portions 261 and the second end portions 262 of the elastic probes 260 where each first end portion 261 has a connecting end and each second end portion 262 has a contact end. At least a portion of the probe metal layer 250 on the edge slopes 223 includes the plurality of elastic bending portions 263 of the elastic probes 260. At least a portion of the probe metal layer 250 on the first flat surface 211 of the substrate 210 includes the middle portions 264 of the elastic probes 260 formed in the recess 222. By means of the elastic bending portion 263 and the middle portion 264 of the elastic probes 260, the penetrating shift directions of the contact ends (one ends of the second end portions 262) are

different from row-arranging direction of the elastic probes 260, almost perpendicular. The elastic probes 260 will not short together during probing an untested IC chip.

In the third embodiment of the present invention, another method for fabricating a plurality of elastic probes in a row is shown from FIGS. 8A to 8G. As shown in FIG. 8A, firstly, a substrate 410 is provided which has a flat surface 411. As shown in FIG. 8B, a recess 412 is created to form in the flat surface 411 of the substrate 410 by etching. The recess 412 has two edge slopes 413 and a bottom 414. In the present embodiment, the included angle between the edge slopes 413 and the bottom 414 ranges from 100 to 170 degrees and the depth of the recess 412 ranges from 2 to 100 micrometers. As shown in FIG. 8C, a release layer 420 is formed on the flat surface 411 and on the edge slopes 413 and the bottom 414 of the recess 412. In the present embodiment, the release layer 420 contains metal titanium to form elastic probes in a row.

As shown in FIG. 8D, a photoresist layer 430 is formed on the release layer 420 by spin coating to locate above the flat surface 411 and in the recess 412. As shown in FIG. 8E, the photoresist layer 430 is patterned by photolithography to form a plurality of slots 431 where the slots 431 extend across the recess 412 of the substrate 410 for forming a plurality of elastic probes 450 in the slots 431.

As shown in FIGS. 8F and 8G, a probe metal layer 440 is formed in the slots 431 to form a plurality of elastic probes 450 in a row. As shown in FIG. 8G, the patterned photoresist layer 430 is stripped so that the elastic probes 450 can separate from the substrate 410. Each of the elastic probes 450 has a first end portion 451, a plurality of elastic bending portions 453, a middle portion 454, and a second end portion 452.

As shown in FIGS. 8F and 8G, at least a portion of the probe metal layer 440 lying on the flat surface 411 of the substrate 410 includes the first end portions 451 and the second end portions 452 of the elastic probes 450. At least a portion of the probe metal layer 440 lying on the bottom 414 of the recess 412 includes the middle portions 454 of the elastic probes 450. Moreover, at least a portion of the probe metal layer 440 lying on the edge slopes 413 of the recess 412 includes the elastic bending portions 453 of the elastic probes 450. In this embodiment, the first end portions 451 have a plurality of connecting ends of the elastic probes 450 for bonding to a probe head and the second end portion 452 have a plurality of contact ends of the elastic probes 450 for chip probing. Therefore, the penetrating shift directions of the elastic probes 450 are parallel each other but different from the row-arranging direction of the elastic probes 450. When probing an untested IC chip, the second end portions 452 of the elastic probes 450 can probe the bonding pads of the IC chip and the shift direction due to overdrives is approximately perpendicular to the arranging direction of the bonding pads so that the probes will not be short to each other and will not damage the bonding pads.

The above description of embodiments of this invention is intended to be illustrative and not limiting. Other embodiments of this invention will be obvious to those skilled in the art in view of the above disclosure.

What is claimed is:

1. A method for fabricating a plurality of elastic probes in a row, wherein each of the elastic probes has a first end portion, a plurality of elastic bending portions, a middle portion, and a second end portion, the method comprising the steps of:

7

providing a substrate having a flat surface;
 creating a recess in the flat surface of the substrate, the
 recess having a bottom and a plurality of inner sides;
 forming a photoresist layer on the flat surface of the
 substrate and in the recess;
 patterning the photoresist layer to form a plurality of slots
 crossing the recess, wherein the slots are connected;
 forming a probe metal layer in the slots of the photoresist
 layer, wherein at least a part of the probe metal layer
 lying on the flat surface of the substrate includes the
 first end portions and the second end portions of the
 elastic probes, at least a part of the probe metal layer
 lying on the bottom of the recess includes the middle
 portions of the elastic probes, at least a part of the probe
 metal layer lying on the inner sides of the recess
 includes the elastic bending portions of the elastic
 probes, wherein the probe metal layer further compris-
 ing a connecting bar integrally connecting to the second
 end portions of the elastic probes;

8

removing the photoresist layer and the substrate;
 mounting the first end portions of the elastic probes in a
 plurality of connecting holes of a probe head; and
 removing the connecting bar after mounting the elastic
 probes.

2. The method of claim 1, wherein the inner sides of the
 recess are slopes.

3. The method of claim 2, wherein the included angle
 between the inner sides and the bottom surface of the recess
 ranges from 100 to 170 degrees, and the depth of the recess
 ranges from 2 to 100 micrometers.

4. The method of claim 1, further comprising the step of
 forming a release layer on the exposed flat surface of the
 substrate and on the inner sides and the bottom of the recess
 prior to forming the photoresist layer.

5. The method of claim 1, wherein the probe head further
 has a plurality of alignment holes for inserting two ends of
 the connecting bar.

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